Supply chain collaboration alternatives: understanding the expected costs and benefits

Tim McLaren, Milena Head and Yufei Yuan

The authors

Tim McLaren is a PhD candidate, **Milena Head** is an Assistant Professor of Information Systems, and **Yufei Yuan** is a Professor of Information Systems, all at the Michael G. DeGroote School of Business, McMaster University, West Hamilton, Ontario, Canada.

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Abstract

Collaboration is a recent trend in supply chain management (SCM) that focuses on joint planning, coordination, and process integration between suppliers, customers, and other partners in a supply chain. Its competitive benefits include cost reductions and increased return on assets, and increased reliability and responsiveness to market needs. Recent advances in inter-enterprise software and communication technologies, along with a growing use of strategic partnering and outsourcing relationships, has resulted in a confusing assortment of alternative information systems approaches for supporting collaborative SCM. This paper analyzes the alternatives and presents a framework for understanding the expected costs and benefits of each type of system. These costs include not only the total cost of ownership of the system, but also the partnership opportunity cost – the cost of being tied to a partner due to system inflexibility. The benefits of collaborative SCM include process, inventory, and product cost reductions as well as increased cycle times, service levels, and market intelligence.

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Introduction

Supply chain management (SCM) is a well-established discipline that involves the coordination of an organization's internal planning, manufacturing, and procurement efforts with those of its external partners (i.e. suppliers, retailers, etc.). To reduce inefficiencies in a supply chain, organizations are increasingly using information systems to integrate the systems and processes throughout their supply chain. Effective supply chain integration and synchronization among partners can eliminate excess inventory, reduce lead times, increase sales, and improve customer service (Anderson and Lee, 1999).

However, mere coordination among trading partners today is no longer enough to maintain a competitive advantage. Instead, companies are moving towards collaborative SCM in an effort to reduce the information imbalances that result in the dreaded "bullwhip effect" (Lee *et al.*, 1997), while increasing their responsiveness to market demands and customer service (Mentzer *et al.*, 2000).

This paper begins with a description and analysis of the various methods for synchronizing supply chain information and processes between organizations such as using electronic data interchange (EDI), joining an electronic marketplace, or utilizing shared collaborative SCM systems. Proponents of these varying methodologies are often self-interested commercial vendors or are organizations that have invested in an initiative themselves and need to convince others to follow suit. Given this bias, and a lack of a suitable framework for analyzing the expected costs and benefits, it is very difficult to determine which approach is most suitable for an organization. This paper presents a cost-benefit framework to address this issue.

Similarly, several previous studies attest to the transaction cost savings of interorganizational systems (Mukhopadhyay *et al.*, 1995; Seidmann and Sundararajan, 1998), but ignore other costs of ownership or opportunity costs of having an inflexible system. We will examine these "hidden costs" in addition to the potential benefits the systems can generate.

Ultimately, this paper will provide a framework for organizations or researchers investigating collaborative SCM to examine the anticipated costs and benefits of the alternative systems. Given the uniqueness of most system implementations, our analysis generalizes the expected costs and benefits of the various alternatives based on previous studies and anecdotal evidence. Based on this evidence, we then make some general conclusions and observations.

We will first begin with an overview of the justification for collaboration followed by an overview of the alternatives.

From business logistics to supply chain collaboration

This section shows details of how business logistics has evolved into supply chain collaboration.

A supply chain is the collection of functional activities through which raw materials are converted into finished products for sale to a customer (Ballou, 1999). The term supply chain management is therefore synonymous with business logistics management, except that the latter is commonly misconstrued to have a narrower connotation focused mainly on transportation of goods. Ballou (1999) uses the term integrated business logistics management to reflect the need to coordinate the management of both the product supply (materials management) and subsequent product delivery (distribution) activities; however, the term supply chain management has proven more popular. Similarly, some authors have felt that the term supply chain has a connotation that is limited to supplier processes and does not emphasize the customer or distribution processes involved. Thus, we have terms such as value chains (Porter, 1985), supply networks, and business webs used interchangeably with supply chain, though their usage is not always consistent. In many cases, a web is a more accurate metaphor than a chain, though the distinction is not important to this article, as transactions still mainly occur between only two partners at one time. Nonetheless, the more traditional term supply chain is used as it is readily understood and emphasizes the interconnected nature of the various functional activities involved in supplying a good or service to a customer.

Businesses in the early part of the twentieth century were often vertically integrated operations, i.e. they performed manufacturing, sourcing, warehousing, sales, and logistics functions "in house". However, by the late 1900s, vertical integration had almost disappeared and most organizations included external partners in their supply chain. Since these external partners (suppliers, transportation providers, retailers, etc.) are outside of the management control of an organization, supply chain management has traditionally involved each organization managing their portion of the supply chain and monitoring their partners to ensure they fulfill their contractual obligations (Ballou, 1999).

There can be numerous problems with this approach, the best known perhaps being the "bullwhip effect", where the effects of uncertainty in demand and lead times cause order sizes and lead times to be inflated the further up the supply chain and away from the end customer you get (Lee *et al.*, 1997). This leads to a much greater amount of excess and obsolete inventory in the supply chain in an effort to protect against stock outs between each link in the chain. However, with increased management coordination of the supply chain and by making end-customer demand information readily available to the entire supply chain, the bullwhip effect can be reduced and there is limited amplification of uncertainty along the chain (Lee *et al.*, 1997).

Thus, while supply chain management focuses on controlling the activities amongst the supply chain partners, supply chain integration focuses on improving the information flow between links in the chain, and supply chain optimization or supply chain coordination focuses on making decisions that reduce the information asymmetry and resulting excess inventory in the supply chain. However, if only the dominant partner drives supply chain optimization decisions, this can create an asymmetrical distribution of information, inventory, and ultimately bargaining power between the partners (Iacovou *et al.*, 1995). Thus, in order to optimize the entire supply network and not just create local optima in one or two partners, the organizations must jointly

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make supply and demand decisions that create sustainable value for all involved. Hence, many organizations are increasingly developing strategic partnerships with their suppliers and customers in an effort to reduce waste in their procurement and order fulfillment processes (Porter, 1985).

Collaborative SCM goes beyond mere exchanging and integrating information between suppliers and their customers, and involves tactical joint decision making among the partners in the areas of collaborative planning, forecasting, distribution, and product design (Kumar, 2001). Collaboration also involves strategic joint decision making about partnerships and network design. The result of collaborative SCM is not only the reduction of waste in the supply chain, but increased responsiveness, customer satisfaction, and competitiveness among all members of the partnership. Thus, collaborative SCM systems allow organizations to progress beyond mere operational-level information exchange and optimization and can transform a business and its partners into more competitive organizations.

It is important to note that true collaboration requires more than simply a focus on optimizing transactional or operational functions. As Walter *et al.* (2001) observe, high-performing collaborative relationships require not only a focus on direct value-creating or buyer-supplier functions, but also an equal focus on the indirect relationship building and sustaining functions.

Many organizations have undertaken information technology supported initiatives to transform their focus from operational buying and selling relationships into higher performing collaborative relationships. Venkatraman (1991) describes five levels of business transformation made possible through information technology (IT) implementation. These are:

(1) localized exploitation;
(2) internal integration;
(3) business process redesign;
(4) business network redesign; and
(5) business scope redefinition.

While organizations do not always perform these stages sequentially, in general, the higher the level, the greater the potential benefits, strategic impact, and degree of organizational change required. The focus of this paper will be on business network redesign which utilized IT resources to redesign the linkages between business partners to create new capabilities, generate favourable asymmetries in the marketplace (Venkatraman, 1991), and integrate business processes between organizations sharing a common value chain (Porter, 1985).

Collaborative SCM systems are designed to support enhanced information sharing and collaborative planning among partners in an effort to reduce information asymmetries in the supply chain, which contribute to the bullwhip effect and result in excess inventories (Lee, 2000). They support collaboration primarily through three mechanisms:

(1) information integration;
(2) process and resource coordination; and
(3) reporting of performance measures to ensure accountability (Lee, 2000).

Traditional purpose-built information systems, which we often term legacy systems, have often focused primarily on meeting only one of these objectives at a time, while more integrated systems such as enterprise resource planning (ERP) applications are better suited to meet all three requirements.

Furthermore, while operational-level inter-enterprise systems such as EDI systems often benefit customers much more than suppliers (Lee *et al.*, 1999), systems that support tactical and strategic collaborative planning help ensure that the benefits of coordination are sustainable and experienced by all members of the chain, not just the customers. This shared value enhances the sustainability of the relationship, while equalizing the bargaining power of the partners (Seidmann and Sundararajan, 1998) and strengthening their level of trust (Karahannas and Jones, 1999).

In summary, organizations can experience a greater level of benefits as their supply chains evolve from an internal focus on business logistics to more collaborative relationships. We have integrated these benefits and their associated costs into the conceptual model presented later in this paper. Using this model,

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the following sections first describe and then analyze each of the alternative systems for supporting the evolution towards more collaborative SCM.

Systems for collaborative SCM

The desire to share information and promote collaborative management of the supply chain causes organizations to increasingly turn to interorganizational information systems (IOS) for supply chain collaboration, referred to here as collaborative SCM systems. Indeed, a supply chain-wide information infrastructure can disseminate supply and demand information throughout the chain in near real time, which greatly reduces the bullwhip effect (van Hoek, 2001) and enables collaboration.

We classify the systems that support these varying degrees of supply chain coordination and collaboration into three major types:

(1) message-based systems that transmit information to partner applications using technologies such as fax, e-mail, EDI, or eXtensible Markup Language (XML) messages;
(2) electronic procurement hubs, portals, or marketplaces that facilitate purchasing of goods or services from electronic catalogues, tenders, or auctions; and
(3) shared collaborative SCM systems that include collaborative planning, forecasting, and replenishment capabilities in addition to electronic procurement functionality.

There are many different types of supply chain IOS, such as EDI or enterprise application integration (EAI) based systems, electronic marketplaces, or even non-computerized phone or fax-based systems. Since there is often confusion over the terms used to classify a particular type of IOS (for example some authors use hub or marketplace interchangeably), we have attempted to use the most widely accepted definitions and explain the key differences between the classifications. Following a brief description of our classification, we will analyze the expected net benefits of usage of each type of system for supporting collaborative SCM.

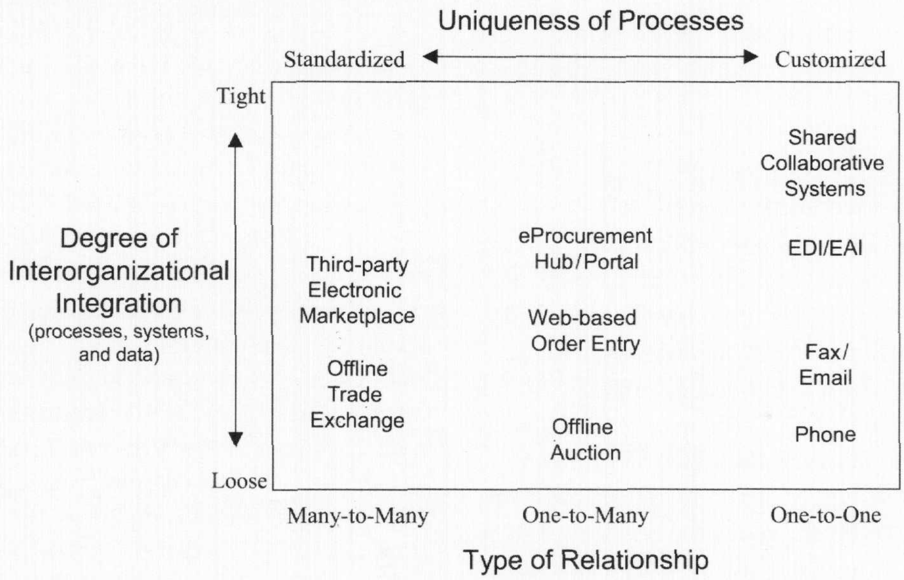
The key differences between the alternative systems are the type of trading relationships and processes they are designed for and the degree of interorganizational integration they support, as shown in Figure 1.

In analyzing the type relationship, we look at the cardinality of the relationships the system is designed to support. In other words, is the system optimized for supporting one-to-one relationships, such as EDI, or many-to-many relationships, such as multiple suppliers and customers interacting in an electronic marketplace? Somewhere in between these extremes lie systems designed for one-to-many relationships such as Web-based order entry systems or auctions. We are not implying that EDI systems cannot be used to interact with dozens of suppliers and customers. Rather, each additional customer-supplier link requires a significant effort to integrate the systems, processes, and data definitions between the two partners, resulting in multiple one-to-one relationships with all of the EDI trading partners. By contrast, once an organization integrates its systems with an electronic marketplace, it can engage in multiple trading relationships with minimal incremental effort.

Similarly, the capability of the systems to support unique or customized supply chain processes between the trading partners coincides with the type of relationship the system is designed for. For example, since electronic marketplaces are designed for many-to-many supplier-to-customer relationships, they require a high degree of standardization of business processes. In contrast, since systems using EDI or EAI involve linkages between one customer and one supplier at a time, they can support much more customized and unique business processes.

The other key variable that distinguishes collaborative SCM systems is the degree of integration achieved or required between the partners. Tight integration implies a close alignment of the trading processes, systems, and data definitions between the partners and communication that allows information to flow efficiently between the organizations. In contrast, loosely integrated trading partners have significant differences in business processes and data definitions that require substantial human intervention to pass

Figure 1 Interorganizational systems for supply chain collaboration



information between the two organizations. Note that even though EDI achieves tight data integration, it often fails to facilitate the harmonization of business processes and systems amongst the trading partners. By comparison, enterprise application integration usually results in closer alignment of business processes and systems as partners are forced to agree upon a process or use the process models embedded in the enterprise systems. Similarly, when joining an electronic marketplace, companies must align their processes and data definitions with the standards enforced by the marketplace.

While this classification of systems and approaches provides a first-cut approximation of which situations each is most appropriate for, it is insufficient for determining the most effective strategy for a given organization. In order to shed more light on the different approaches in Figure 1, we briefly describe each in the following section.

Phone/fax/e-mail systems

Traditionally, many supply chain activities have involved the usage of manual and semi-automated phone, fax, and e-mail systems in addition to face-to-face and paper-based transactions. For many functions such as establishing relationships and initial contract negotiations, these methods are indispensable and unlikely to be replaced completely by more automated systems. However, many supply chain processes can be made much more efficient by employing information technology to improve information sharing, reduce errors and rework, and free resources to work on more value-added tasks (O'Leary, 2000).

Phone, fax, and e-mail systems all support highly flexible and customized trading relationships, though they lack standards in their usage. They are very suited for communicating unstructured information, but do not support communicating structured information into the recipients' systems electronically. As a result, they do not support a very tight degree of interorganizational integration. While e-mail systems can transmit structured information such as electronic purchase orders directly into a recipient's system, we classify that type of system as EDI. In our classification, we assume that phone, fax, and e-mail messages contain unstructured text or images.

Offline auctions/trade exchanges

Offline auctions involve one supplier and many customers (in a forward auction) or one customer and many suppliers (in a reverse auction). As the auction process usually focuses on price as the prime decision variable, they have had the widest acceptance in commodity markets.

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Similarly, offline trade exchanges help coordinate similar markets, yet are designed to support many-to-many relationships. Both offline auctions and trade exchanges support only a limited degree of interorganizational integration, as the systems and data are not electronically integrated, and the business processes amongst the trading partners are often disparate and uncoordinated. As a result, many former offline auctions and exchanges have migrated to online electronic marketplaces to increase the benefits of integration and coordination amongst their members (for example, the General Electric Trading Exchange).

Web-based order entry systems

Web-based order entry systems, sometimes referred to as business-to-consumer (B2C) or business-to-business (B2B) Web sites or customer portals, enable customers to directly interact with a supplier's sales order system. As opposed to eProcurement applications, Web-based order entry systems reside on the supplier's computers. Since the customer manually enters the information, the degree of systems and data integration between the customer and supplier is loose, even though the supplier's systems may be internally integrated. Furthermore, since the customer must conform to the supplier's business processes, the degree of process integration or coordination between the two parties is also loose.

If transactions are predominately communicated electronically rather than entered manually, we classify those systems as EDI or EAI systems as appropriate.

Electronic procurement hub/portal

Web-based procurement systems reside on a customer's systems and allow the customer to electronically integrate its systems and processes to some degree with those of its suppliers. In general, an eProcurement system or portal refers to a Web site operated by a customer which contains information integrated from its suppliers' systems. Often, the site includes electronic catalogues from the suppliers, and includes functionality to submit purchase orders electronically to the supplier from within the portal application. Typically, the customer performs most of the effort of integrating the supplier catalogues into the eProcurement system.

In contrast, the term e-hub or supplier portal usually refers to a Web site belonging to a customer that allows its suppliers to integrate their systems and processes with those of the organization (Stevens, 2001). In this paper, electronic procurement portals or hubs are assumed private infrastructures, rather than the public third-party electronic marketplaces that are described in a later section.

Electronic data interchange/enterprise application integration

The traditional method for businesses to exchange structured operational information electronically has been to use electronic data interchange (EDI). Strictly speaking, EDI is not a type of system, but rather a standards-based messaging methodology for formatting and communicating business transactions between organizations. While electronic marketplaces and procurement systems may utilize EDI messages, they provide a higher degree of process coordination and enable transactions between multiple parties rather than the one-to-one communications of what we refer to as EDI systems.

Similarly, enterprise application integration (EAI) is also a standards-based messaging approach to integrating systems, though it usually implies the use of XML-formatted messages and integrated enterprise-wide systems. EAI in a supply chain usually involves one-to-one integration between enterprise applications including legacy systems, ERP, SCM, or advanced planning and scheduling (APS) systems.

While XML is more flexible than EDI for formatting messages, like traditional EDI, it requires trading partners to adhere to common standards for defining the business processes and for formatting and using the data. Although XML usage is rapidly evolving, currently there is little to distinguish XML-based EAI from more traditional EDI.

Third-party electronic marketplaces

Electronic marketplaces are online business-to-business (B2B) communities that link participants to a global network of buyers and sellers (Stevens, 2001). They usually include capabilities for product sourcing and ordering such as electronic catalogues, online auctions, and sometimes include approvals routing and contract management capabilities (Archer and Gebauer, 2000). A third party such as CommerceOne, eSteel, or W.W. Grainger typically hosts the marketplaces (Kaplan and Sawhney, 2000). While some organizations are developing their own private marketplaces, we could classify these as eProcurement solutions. Therefore, we will only consider the unique characteristics of third-party electronic marketplaces.

Shared collaborative SCM systems

So far, we have looked at various methods and technologies that can help integrate the systems, data, and business processes among two or more partners in a supply chain. While each of these alternatives differs in the degree of strategic collaboration supported, they are all similar in their approach of facilitating collaboration through system integration.

In contrast, the use of shared collaborative SCM systems takes a different approach by eliminating much of the integration and translation efforts agreeing upon shared processes and systems. Examples of these systems include jointly owned SCM systems or SCM modules from ERP or APS packages that have been made accessible for partner access and collaboration.

Shared collaborative supply chain systems are designed for trading partners to perform joint supply chain planning, design, and optimization rather than to simply facilitate the exchange of information between the partners. They accomplish this by sharing a single system for both partners, rather than by attempting to integrate separate systems. Nonetheless, there are costs for each party for integrating their other SCM systems with the shared system.

Like each of the alternatives, there are trade-offs between the benefits and the costs of using collaborative systems. We discuss these trade-offs in the following section.

Conceptual model of alternatives

The benefits of collaboration include reduced process costs, inventory levels, and product costs that result from the coordination of actual customer demand with supplier production plans (Mentzer *et al.*, 2000). Furthermore, Mentzer *et al.* (2000) found that collaboration also resulted in faster product-to-market cycle times, improved service levels (based on stock outs, lead times, and quality), and a better understanding of end-customer needs throughout the entire chain (market intelligence). Figure 2 shows that these benefits fall into two broad categories: enhanced responsiveness to market and reduced supply chain costs.

The costs involved in collaborative SCM fall into two broad categories: the total cost of ownership (TCO) of the system as well the partnership opportunity cost (the cost associated with being tied into a specific partner). TCO consists of the total lifecycle costs of the chosen processes and systems including cost of systems acquisition, usage, maintenance, dealing with errors and inefficiencies, and integration with partners over the lifetime of the solution (Degraeve and Roodhooft, 1999). As shown in Figure 2, the components of TCO include costs of systems implementation and integration, coordinating and integrating business processes among partners, and translating and integrating data among systems.

The analysis of costs must account for the opportunity costs of sustaining and changing partnerships and processes. The partnership opportunity cost represents the value of the benefits forgone by not adopting a more beneficial partnership (after Gibbins, 1995). It includes the costs of switching partners and the partnership instability cost (costs due to the frequency of partnership changes). For example, inflexible systems such as EDI have high costs for switching to other partners, which contributes to a higher partnership opportunity cost (Poirier and Bauer, 2001). However, if partnerships are stable and long-term, the partnership instability cost is low resulting in a more moderate partnership opportunity cost.

Systems that do not promote long-term relationships (such as many auction-based systems) will result in instable relationships and a high partnership instability cost. This instability results in the partners forgoing the benefits of long-term collaboration, resulting in

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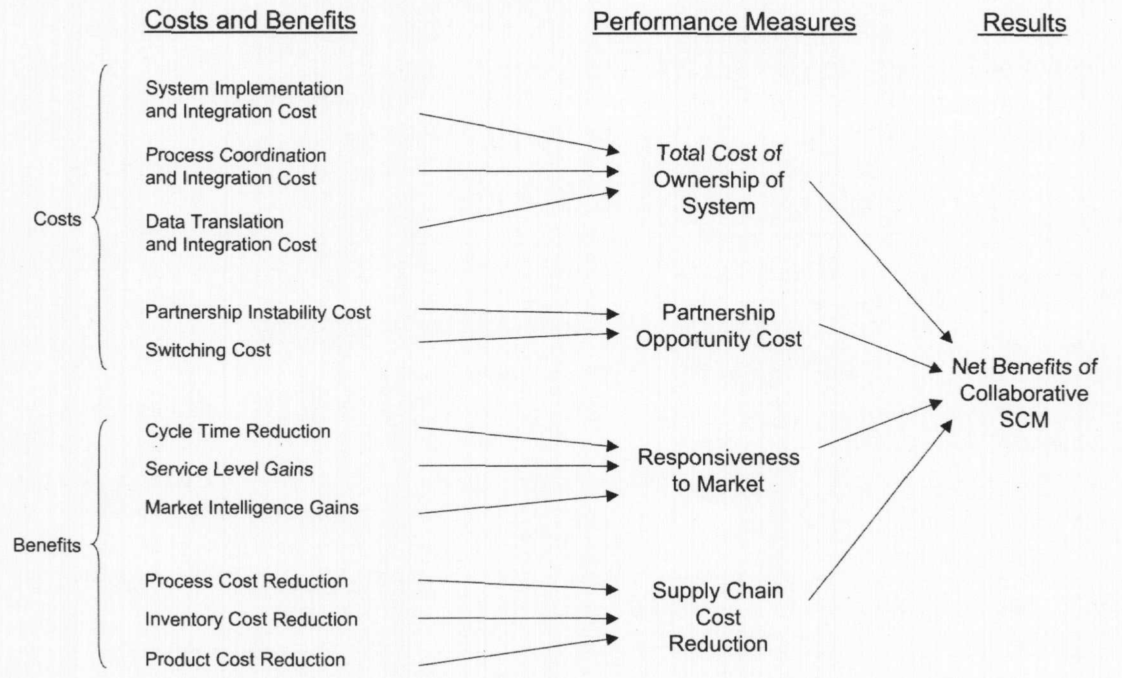
Figure 2 Cost-benefit model for collaborative SCM systems



a high partnership opportunity cost, even though the switching costs in auctions are low (Anderson and Lee, 1999). Therefore, a high partnership opportunity cost can result from either high switching costs or high partnership instability, or both.

It is important to note that in collaborative SCM, low switching costs are desirable for most situations. At first, this may seem contrary to Porter's (1985) suggestion that high switching costs are desirable for preventing customers from trading with other partners. However, as we have discussed, low costs of switching partners enables organizations to more easily support the relationships that are the most beneficial to the organization and thus lower the opportunity cost associated with a partnership. Furthermore, several studies have suggested that partnerships that are maintained through coercion, threats, or high switching costs fail to provide the equity of benefits to both parties that are required for sustainable collaboration (Kumar and van Dissel, 1996; Iacovou *et al.*, 1995).

The overall cost of the system is the sum of the total cost of ownership and the opportunity cost of inflexibility. The net benefit of the collaborative SCM system is therefore the benefit resulting from enhanced market responsiveness and reduction of supply chain costs less the cost of ownership and opportunity costs, as shown in Figure 2.

In the following section, we examine each of the alternative systems for collaborative SCM, and analyze their potential costs and benefits using the above conceptual model.

Expected costs and benefits of collaborative SCM systems

The following analysis generalizes the expected benefits and expected costs of each of the alternative collaborative SCM systems, as shown in Tables I and II, respectively. Since the implementations of the various systems are as unique as the organizations that use them, there is little value in trying to do direct empirical comparisons between the systems. Instead, we can make some conclusions and observations based on previous studies and anecdotal evidence.

Phone/fax/e-mail systems

Compared to paper-based or in-person transactions, the use of telephones for supply chain transactions can increase the efficiency of the transactions involved. However, as the

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Table I Expected benefits of collaborative SCM systems

Benefits	Phone/fax/ email	Offline auction/trade exchange	Web-based order entry	Electronic procurement hub/portal	Third-party electronic marketplace	Electronic data interchange/ EAI	Shared collaborative systems
Responsiveness to market							
Cycle time reduction (supply chain process velocity)	Low	Low	Medium	High	High	High	High
Service level gains (quality, timeliness, and satisfaction)	Low	Low	Medium	High	High	High	High
Market intelligence gains (understanding customer needs)	Low	Low	Medium	Medium	Medium	Medium	High
Supply chain cost reduction							
Process cost reduction	Low	Medium	Medium	High	High	High	High
Inventory cost reduction	Low	Low	Low	Medium	Medium	High	High
Product cost reduction	Low	Medium	Low	High	High	Medium	Medium
Overall benefit	Low	Low	Medium	High	High	High	High

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Table II Expected costs of collaborative SCM systems

Benefits	Phone/fax/ e-mail	Offline auction/trade exchange	Web-based order entry	Electronic procurement hub/portal	Third-party electronic marketplace	Electronic data interchange/ EAI	Shared collaborative systems
Total cost of ownership of system							
Process coordination and integration cost	Low	Low	Low	High	High	Medium	High
System implementation and integration cost	Low	Low	Low	Medium	Medium	High	Medium
Data translation and integration cost	Medium	Medium	Medium	High	High	High	High
Partnership opportunity cost							
Switching cost (from changed partners or processes)	Low	Low	Low	Medium	Low	High	High
Partnership instability cost (switching frequency)	Low	High[a]	Low	Medium	High[a]	Medium[b]	Low
Overall cost	Low	Medium	Low	Medium	Medium	High	Medium

Note: [a] Sustainability of relationship is limited, as many suppliers today feel that marketplaces and auctions force them to compete mainly on price and hence reduce their bargaining power (Stevens, 2001). The cost could be lower if marketplace supports multi-attribute negotiations (in addition to price) and suppliers perceive more benefits and bargaining power; [b] Sustainability of relationship is limited, as system is generally perceived to be in favour of buyer (Lee *et al.*, 1999). Cost could be lower if planning information such as demand forecasts and sales plans are shared with suppliers, though this requires significant incremental effort and increases the cost of ownership

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information communicated is not integrated with any other systems, these efficiency gains are minimal, and may be offset by an increased likelihood of errors.

Fax and e-mail systems yield greater process gains over phone systems, especially when they are integrated with the sender's information systems. However, as can be seen in Table I, the increased benefits are not as substantial as more sophisticated and integrated supply chain systems.

The net benefits accrued from information sharing using phone, fax, and e-mail systems are limited mainly by the fact that the information communicated is difficult to integrate into the receiver's systems without manual processing and data translation. As shown in Table II, the total cost of ownership of these systems is generally low, except for the cost of data translation and integration, which is medium, since it is a labour-intensive activity.

The usage of phone, fax, and e-mail systems results in relatively low partnership opportunity costs as the unintegrated nature of the systems keeps the switching costs low. Also, the higher search costs for finding new partners with these systems (Bakos, 1997) acts as a disincentive for frequent partnership switching resulting in a low partnership instability cost (see Table II). As they can be more automated and communicate richer information, e-mail systems do offer more process gains than phone or fax systems, but at a proportionately greater total cost of ownership, due to their support and infrastructure costs. The use of e-mail to transmit structured data directly to other systems is better classified as a type of EDI and is discussed later.

Offline auctions/trade exchanges

Traditional offline auctions and offline trade exchanges are widely believed to yield benefits to a supply chain in increased market efficiency and reduced searching costs, which results in a moderate product and process cost reduction. However, as the information exchanged is typically not integrated with any systems, there is minimal benefit in terms of increased responsiveness of the supply chain or reduction of inventory (see Table I).

Furthermore, the unintegrated nature of the systems results in ownership costs similar to phone, fax, or e-mail systems, since manual data entry and translation is usually required. In addition, auctions that focus mainly on price reduce the bargaining power of suppliers, preventing them from maintaining long-term collaborative relationships, which results in a higher partnership instability cost (Stevens, 2001). However, this cost could be lowered if the auctions support multi-attribute negotiations (in addition to price) and suppliers perceive more benefits and bargaining power (see Table II).

In summary, offline auctions require a considerable human effort to perform data and process translations between the partners, yet fail to adequately support tactical or strategic information sharing or collaboration.

Web-based order entry systems

With Web-based order entry systems, the information exchanged between the customer and supplier is consistent with the supplier's system, resulting in a lower error rate and minimal rework of the information, as compared to voice- or paper-based transactions. However, while the supplier does not need to translate the information (as it is already entered into their system) the customer is required to do a mental translation of their processes and information into the process and format required by the supplier's order entry system. Thus, the supplier experiences efficiency gains from the integration, while the customer experiences fewer such benefits, especially after having to learn how to interact with several different supplier Web sites.

In a system that benefits the supplier much more than the customer, the efficiency gains of integration are self-limiting because the customers will tend to seek out relationships that are more desirable. As a result, organizations participating in supply chains primarily dependent on Web-based order entry systems will experience a moderate level of cycle time reduction, service level gains, and market intelligence gains due to the partial integration of information (Table I). However, these gains are not as much as the remaining alternatives, which offer fuller integration of information between both trading partners.

As shown in Table II, Web-based order entry systems have a total cost of ownership and

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partnership opportunity cost that is comparable to phone, fax, or e-mail systems, though the system integration costs are usually somewhat higher.

Another important aspect of these systems is that they are primarily designed for supporting transactional information processing, rather than tactical or strategic supply chain collaboration. For example, most Web-based order entry systems do not make tactical information such as actual product availability or lead times available, which would provide more of a benefit to their customers. Furthermore, as the customer's systems are not integrated with those of the supplier, there is little to tie them into the relationship and thus the switching costs are low. Fortunately, the low switching costs mean the flexibility of the supply chain partnerships is high and the opportunity costs of being tied to specific partners is low.

Thus, Tables I and II show that while the opportunity and switching costs are low for Web-based order entry systems, the benefit of strategic information sharing and collaboration are also low. Note, that if strategic planning information were made available to the customers on the Web site, such as "available-to-promise" data, then the collaboration gains would increase. However, again, the lack of integration with the customers' systems and processes would limit the gains realized. Note that if the information were integrated with the customer systems, then the system would be better termed a hub or portal as described in the following section.

Electronic procurement hub/portal

Electronic procurement portals and hubs increase the efficiency of trading partners by integrating the data, processes, and systems utilized in a supply chain. They can lead to lower product prices through spending consolidation and process efficiencies (Archer and Yuan, 2000); however, the biggest savings come from purchasing compliance by reducing off-contract buying and forcing purchases to be made against established contracts (Hope-Ross *et al.*, 2000). Thus, Table II shows these systems have a high potential for cycle time reduction, service level gains, and process and product cost reductions. However, since they do not focus on the exchange of supply and demand information, the inventory cost reduction and market intelligence benefits are not as high as for EDI, EAI, or collaborative supply chain systems.

The benefits of electronic procurement solutions are often offset by the large integration and translation efforts required to facilitate the electronic transactions amongst the partners (Archer and Gebauer, 2000). Though they can result in lower transaction costs, the cost of maintaining different electronic catalogues for different customers and from integrating these into another organizations systems is high (Ginsburg *et al.*, 1999), resulting in a significant total cost of ownership over the lifetime of the partnership, as shown in Table II.

Similarly, this integration inflexibility carries significant switching and opportunity costs as costs are sunk into maintaining the existing relationships and information-sharing capabilities (Archer and Yuan, 2000). The ability to share strategic planning information amongst the supply chain partners is often better than with organizations without any type of inter-enterprise integration, however, it is still limited. Thus, Tables I and II show that these systems yield only moderate benefits from collaboration, though they have lower opportunity costs and costs of ownership than the following systems, which are better suited for a higher level of supply chain collaboration.

Electronic data interchange/enterprise application integration

Partners in a supply chain have long used EDI for exchanging sales orders electronically (Lee *et al.*, 1999). More recently, supply chains have adopted technologies such as enterprise application integration to achieve the same benefits of electronic information exchange in a more flexible manner using the Internet and XML message formats. However, both EDI and EAI approaches share the same characteristics of standards-based messaging and their expected costs and benefits in Figure 2 are very similar.

Numerous studies have shown that EDI can reduce transaction-processing costs to near-negligible levels (Mukhopadhyay *et al.*, 1995; O'Leary, 2000). However, the total cost of ownership of EDI systems is substantial due

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to the systems and data integration efforts required (see Table I). Furthermore, this integration effort usually requires a large amount of "hard-coded" data translations, which results in a system that is less flexible in adapting to changing partners, processes, and data structures. The result is a high cost of switching partners, as shown in Table II.

While EDI provides definitions for common message formats to be exchanged, its rigid data model and inflexible formatting requirements force trading partners to expend considerable effort in formatting the data to be exchanged and agreeing upon a common data model to be used (Mukhopadhyay *et al.*, 1995). Furthermore, the systems are proprietary, complex, and costly, and sometimes require smaller partners to be coerced into implementing them (Archer and Gebauer, 2000; Lee *et al.*, 1999). As Moore (2001) observed, the result is that EDI relationships cannot be implemented easily, quickly, or inexpensively. This is because the EDI standards focus more on defining the rigid message structures and less on defining which data fields are required for a transaction and how the information should be interpreted.

As a result, two trading partners wishing to exchange EDI messages need to first agree upon how to structure and interpret the messages and then configure their systems to translate their legacy data into this common format. If one of the partners then wanted to exchange EDI messages with a third organization, it would need to start the negotiations all over again with that party in order to adopt a common data model (Moore, 2001). As each party would like to use their own data model and minimize the data translation required, the likely outcome is that organizations would need to translate their data separately for each of their trading partners rather than being able to use one common model. The result is high system and data integration costs. On the positive side, since EDI and EAI participants must adhere to common standards, the costs of coordinating their processes are lower than most of the alternatives (see Table II).

Third-party electronic marketplaces

Electronic marketplaces are useful for coordinating supply chains for some organizations, but like EDI, are not as widely accepted as has been predicted. Stevens (2001) suggests that there are several obstacles to participating fruitfully in an electronic marketplace including supplier resistance, buyer resistance, connectivity, and return on investment (ROI) issues.

Suppliers have been reluctant to join electronic marketplaces as they usually involve highly competitive auction processes focused primarily on price, resulting in unsustainably low prices and a high partnership instability cost similar to offline auctions. However, unlike offline auctions, the system implementation costs are somewhat higher due to the technology integration requirements (see Table II).

In order to gain more acceptance with suppliers, such marketplaces will need to provide negotiation support on other terms such as quality, service level, and payment terms and support longer-term contracts. Otherwise, many suppliers will continue to focus more on building less flexible one-to-one relationships with their strategic partners (Stevens, 2001).

Likewise, buyers are hesitant to join marketplaces that do not support the robust types of negotiations that are required for long-term successful relationships. They also have legitimate concerns about having their supply chain transactions and planning forecasts so easily visible to their competitors in the marketplace. Furthermore, buyers in industry-specific marketplaces have found it difficult to come to agreement with their business rivals upon the required infrastructure, processes, and standards required to support the transactions.

Ultimately, despite the low infrastructure costs of the Internet and the emergence of promising technologies such as XML, the present state of B2B connectivity has not progressed far beyond the rigid standards of EDI. While the Internet has reduced the cost of bandwidth, most trading situations still require significant investment to translate legacy data into some format agreed upon by the marketplace participants (Ginsburg *et al.*, 1999), as shown in Table II. Since there is presently no agreed-upon standard that is sufficiently flexible to accommodate all trading partners, organizations must expend a significant amount of resources to set up those linkages to the marketplace and their other partners. Similarly, the lack of clear standards results in a high process coordination cost between the trading partners, as shown in Table II. In many cases, it has been impossible to meet the ROI requirements of less than a year, which has become standard in many information technology (IT) investments (Stevens, 2001).

The result has been that few electronic marketplaces have achieved the trading volumes originally budgeted for and many have been dissolved within years of their launch. Nonetheless, as technology and standards evolve, like electronic procurement hubs and portals, electronic marketplaces hold considerable promise for reducing transaction costs and enabling tighter collaboration throughout the supply chain (see Table I).

Shared collaborative systems

Collaborative supply chain systems go beyond mere sharing of operational data such as production schedules and available-to-promise capabilities. They also facilitate exchange and coordination of tactical information such as supply and demand forecasts, and may even assist strategic planning through trade network design and optimization (Kumar, 2001).

Through their support of joint planning initiatives such as collaborative planning, forecasting, and replenishment (CPFR), shared collaborative SCM systems can greatly reduce the "bullwhip effect" and yield more accurate demand forecasts. Both the supplier and customer jointly agree upon supply and demand forecasts and plans and can coordinate their promotion and distribution strategies. The result is more predictable demand, which lessens the amount of inventory required in the supply chain and reduces the amount of exception processing and expediting required, leading to cycle time reduction and service level gains (Anderson and Lee, 1999; Mentzer *et al.*, 2000). Furthermore, the joint collaboration allows a high level of market intelligence sharing throughout the supply chain, as customers, distributors, and suppliers can all share information about customer needs (Anderson and Lee, 1999). Thus, Table I shows that the overall benefits for shared collaborative SCM systems are expected to be high.

The process coordination costs are high as the systems are shared among partners each having their own unique business processes. Similarly, both parties must agree upon a mutual data format and must translate and integrate the shared data with their own systems, resulting in a high data translation and integration cost. However, since the shared system acts like a single hub, the system integration costs are not as high as in the point-to-point EDI or EAI solutions, and are comparable to the system integration costs of centralized electronic procurement or marketplace solutions (see Table II). As Ginsburg *et al.* (1999) explain, the system interface costs are a function of the number of partners that need a different system interface, and therefore the centralized or shared systems are expected to have lower system integration costs than the point-to-point solutions.

Furthermore, since two or more partners invest in the shared system, the cost of switching partners is high. However, since the collaborative systems usually have large benefits for both the customers and the suppliers in a trading relationship (Anderson and Lee, 1999), we expect the relationships will be sustainable and the partnership instability cost will be low (see Table II).

Expected net benefits of collaborative SCM systems

As shown in Figure 2, the net benefits of a collaborative SCM system are derived from the total costs of ownership, the opportunity costs due to inflexibility, the enhanced market responsiveness, and the amount of supply chain cost reduction. In Figure 3, we have summarized the relative costs and benefits of the alternative systems for collaborative SCM. In general, the lowest cost alternatives yield the least amount of benefit from collaboration. Similarly, the alternatives offering the high potential benefits of collaboration have moderate costs of ownership and opportunity

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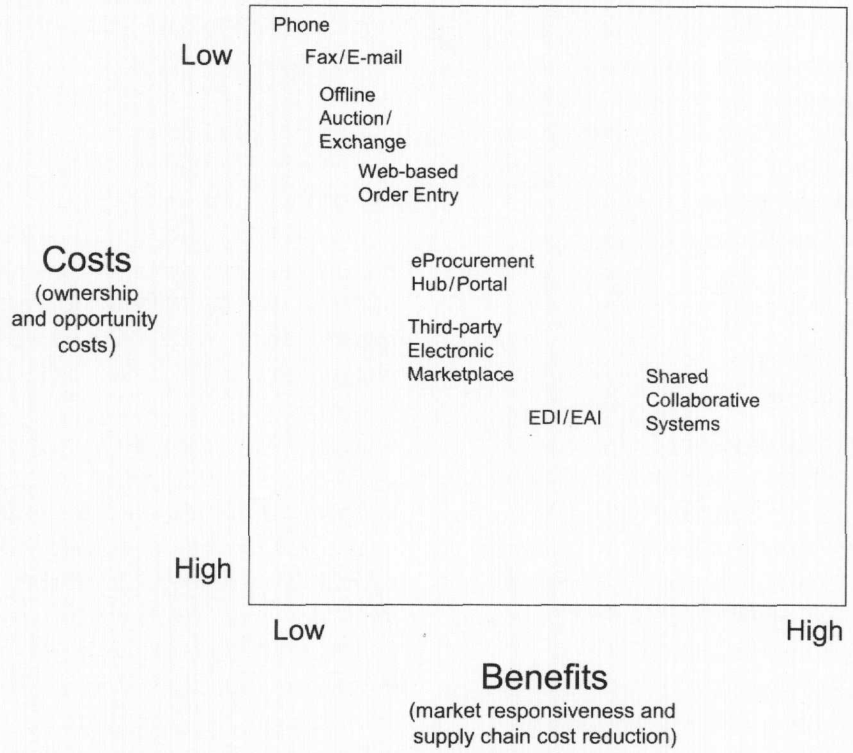
Figure 3 Expected overall cost-benefit of supply chain collaboration systems



costs. The exception is EDI systems, which we expect to have high opportunity costs due to their inflexibility and a high total cost of ownership due to high ongoing system and data integration costs.

Figure 3 is a generalization intended to show the relative costs and benefits that can be expected from different approaches to collaborative SCM. The actual costs and benefits that could be expected would depend upon the functionality that the systems support and how they are implemented and integrated with existing systems and processes. The cost-benefit model shown in Figure 2 should be used as a guideline to anticipate costs and benefits for any specific supply chain collaboration initiative.

Conclusions and directions for further research

Through a comprehensive review of previous research, we have shown that collaborative SCM can result in significant benefits to an organization. These benefits include not only supply chain cost reduction, but also an increased market responsiveness that should result in top-line revenue growth. We have described the alternative systems for supporting supply chain collaboration, and highlighted the different potential each has in achieving these benefits.

We have also described the anticipated costs of each system, which are due not only to implementing, using, and maintaining the systems, but also the cost of integrating the systems, processes, and data within and between organizations. Many previous studies attest to the transaction cost savings of these interorganizational systems, but ignore the switching costs required to change partners or business processes, and also the opportunity costs of not having a system flexible enough to do business with whichever partner is most suitable.

Finally, we have shown that not all of the alternatives considered will achieve the same level of business transformation in the supply chain. Similarly, even though we attempt to make some general cost-benefit comparisons, we acknowledge that not all of the alternatives are equally appropriate for a given organization. While supply chain collaboration is an assumed

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goal, the choice of system will also depend on whether the organization seeks to maximize efficiency and integration, flexibility, or system comprehensiveness.

Clearly, the generalizations and hypotheses made in this paper need to be followed up with additional empirical research. This paper was not intended to be used as a guide in choosing between the different collaborative SCM alternatives, rather it has attempted to build a conceptual cost-benefit model that would be helpful in analyzing and comparing similar systems. In collating a wide variety of research on these disparate systems, we have attempted to highlight the key benefits and challenges of each in order to enable investigations that are more detailed.

This paper has established the justification for a higher level of collaboration between supply chain partners. By looking at the individual factors that influence the net benefits of the alternative systems, the cost-benefit framework we have developed enables a deeper understanding of the alternatives for collaborative SCM. The framework will be useful in designing empirical studies to further examine the relationships between the cost and benefit drivers and the net benefits or successfulness of the implementations.

Further studies should also consider the factors that contribute to each of the summary level cost and benefit drivers presented in this paper. For example, preliminary studies suggest that the benefits of collaboration are influenced by the degree of goal alignment between trading partners (Quinn, 1999) or the level of trust (Karahannas and Jones, 1999). Furthermore, this paper considers costs in terms of ownership, integration, and implementation costs, but does not look specifically at the risks of collaboration at a detailed level. Further studies should address the potential risks in sharing proprietary information, to provide insights into achieving an optimal balance of collaboration and risk management.

Finally, given the strategic importance of supply chain collaboration for many organizations, there is a clear need to further investigate and validate the models put forward in this study.

References

Anderson, D.L. and Lee, H.L. (1999), "Synchronized supply chains: the new frontier", in Anderson, D. (Ed.), *Achieving Supply Chain Excellence Through Technology*, Montgomery Research, San Francisco, CA.

Archer, N. and Gebauer, J. (2000), "Managing in the context of the new electronic marketplace", *Conference Proceedings of the 1st World Congress on the Management of Electronic Commerce*, Hamilton.

Archer, N. and Yuan, Y. (2000), "Managing business-to-business relationships throughout the e-commerce procurement life cycle", *Internet Research: Electronic Networking Applications and Policy*, Vol. 10 No. 5, pp. 385-95.

Bakos, J.Y. (1997), "Reducing buyer search costs: implications for electronic marketplaces", *Management Science*, Vol. 43 No. 12, pp. 1676-92.

Ballou, R.H. (1999), *Business Logistics Management*, Prentice Hall, Upper Saddle River, NJ.

Degraeve, Z. and Roodhooft, F. (1999), "Effectively selecting suppliers using total cost of ownership", *Journal of Supply Chain Management*, Vol. 35 No. 1, pp. 5-10.

Gibbins, M. (1995), *Financial Accounting: An Integrated Approach*, Nelson Canada, Scarborough, p. 650.

Ginsburg, M., Gebauer, J. and Segev, A. (1999), "Multi-vendor electronic catalogues to support procurement: current practice and future directions", *Conference Proceedings of Global Networked Organizations: 12th International Bled Electronic Commerce Conference*, Bled.

Hope-Ross, D., Lett, B., Luebbers, J. and Reilly, B. (2000), "Real e-procurement savings do not come from software", *Electronic Commerce and Extranet Applications (ECEA) Research Note*, GartnerGroup, Stamford, CT.

Iacovou, C.L., Benbasat, I. and Dexter, A.S. (1995), "Electronic data interchange and small organizations: adoption and impact of technology", *MIS Quarterly*, Vol. 19 No. 4, pp. 465-85.

Kaplan, S. and Sawhney, M. (2000), "E-hubs: the new B2B marketplaces", *Harvard Business Review*, May/June, pp. 97-103.

Karahannas, M.V. and Jones, M. (1999), "Interorganizational systems and trust in strategic alliances", *Proceedings of the 20th International Conference on Information Systems*, Charlotte, NC, pp. 346-57.

Kumar, K. (2001), "Technologies for supporting supply chain management", *Communications of the ACM*, Vol. 44 No. 6, pp. 58-61.

Kumar, K. and van Dissel, H.G. (1996), "Sustainable collaboration: managing conflict and cooperation in interorganizational systems", *MIS Quarterly*, Vol. 20 No. 3, pp. 279-99.

Lee, H.G., Clark, T. and Tam, K.T. (1999), "Research report. Can EDI benefit adopters?", *Information Systems Research*, Vol. 10 No. 2, pp. 186-95.

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Lee, H.L. (2000), "Creating value through supply chain integration", *Supply Chain Management Review*, September/October.

Lee, H.L., Padmanabhan, V. and Whang, S. (1997), "Information distortion in a supply chain: the bullwhip effect", *Management Science*, Vol. 43 No. 4, pp. 546-58.

Mentzer, J.T., Foggin, J.H. and Golicic, S.L. (2000), "Collaboration: the enablers, impediments, and benefits", *Supply Chain Management Review*, September/October.

Moore, S.A. (2001), "A foundation for flexible electronic communication", *Information Systems Research*, Vol. 12 No. 1, pp. 34-62.

Mukhopadhyay, T., Kekre, S. and Kalathur, S. (1995), "Business value of information technology: a study of electronic data interchange", *MIS Quarterly*, Vol. 19 No. 2, pp. 137-56.

O'Leary, D.E. (2000), "Supply chain processes and relationships for electronic commerce", in Strader, T. and Whinston, A. (Eds), *Handbook on Electronic Commerce*, Springer-Verlag, Berlin, Heidelberg.

Poirier, C.C. and Bauer, M.J. (2001), *E-Supply Chain: Using the Internet to Revolutionize Your Business*, Berrett-Koehler Publishers, San Francisco, CA.

Porter, M.E. (1985), *Competitive Advantage: Creating And Sustaining Superior Performance*, Free Press, New York, NY.

Quinn, F. (1999), "Collaboration: more than just technology", in Anderson, D. (Ed.), *Achieving Supply Chain Excellence Through Technology*, Montgomery Research, San Francisco, CA.

Seidmann, A. and Sundararajan, A. (1998), "Sharing logistics information across organizations: technology, competition and contracting", *Information Technology and Industry Competition: How It Shapes Competition*, Kluwer Academic Publishers, Boston, MA, pp. 107-36.

Stevens, D. (2001), "Boom, bust and E-hubs", *Backbone Magazine*, July, p. 30.

van Hoek, R. (2001), "E-supply chains virtually non-existing", *Supply Chain Management*, Vol. 6 No. 1, pp. 21-8.

Venkatraman, N. (1991), "IT-induced business reconfiguration", in Morton, S. (Ed.), *The Corporation of the 1990s: IT and Organizational Transformation*, John Wiley & Sons, London, pp. 122-47.

Walter, A., Ritter, T. and Gemunden, H.G. (2001), "Value creation in buyer-seller relationships: theoretical considerations and empirical results from a supplier's perspective", *Industrial Marketing Management*, Vol. 30 No. 4, pp. 365-77.